

AMENDMENTS TO THE CLAIMS

Claims 1-19 (cancelled).

19. (Amended Three Times) An interface device for enabling a user to spatially navigate a displayed graphical menu with a displayed graphical pointer, said graphical menu having a plurality of menu elements, and for enabling said user to more easily select a menu element from said graphical menu by providing tactile feedback to said user when said graphical pointer is moved from a first menu element to a second menu element in said graphical menu, said interface device comprising:

(a) a handle to be manipulated manually by a user in at least two planar degrees of freedom;

(b) a z-axis actuator generating tactile sensations to be felt by said user, wherein said z-axis actuator applies forces to a user's hand only along a z-axis degree of freedom when current is flowed through a portion of said actuator, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom;

(c) a sensor that produces a locative signal responsive to and corresponding with a motion of said handle in said at least two degrees of freedom;

(d) a button that produces a status signal in response to being pressed by said user;
and

(e) an embedded microprocessor local to said interface device and coupled to said sensor, to said button, and to said actuator, said microprocessor performing:

sending handle movement data and button data to a host computer over a communication bus such that said host computer can update displayed pointer locations with respect to said displayed graphical menu,

receiving desired force values from said host computer, said desired force values correlated with particular pointer locations displayed by said host computer; and
controlling said z-axis actuator in accordance with said received desired force values so as to provide said tactile sensations to said user that are correlated with a location of said displayed graphical pointer displayed within said graphical menu.

20. (Amended Three Times) An interface device as recited in claim 19 wherein said z-axis actuator imparts said tactile sensations upon said handle along a z-axis orthogonal to said at least two planar degrees of freedom.

21. (Amended One Time) An interface device as recited in claim 19 wherein said handle is physically coupled to a support mechanism that is grounded and allows linear displacement between said handle and an origin.

22. (Amended One Time) An interface device as recited in claim 19 wherein said sensor is an optical sensor that includes an emitter and a detector.

23. (Amended One Time) An interface device as recited in claim 22 wherein said emitter moves when said handle is moved, projecting light upon said detector.

24. (Amended One Time) An interface device as recited in claim 23 wherein said detector detects motion of said emitter in two mutually perpendicular directions.

25-26. (Canceled)

27. (Amended Two Times) An interface device as recited in claim 19 further comprising a memory that stores values that are representative of a location [the locations] of an image [images] displayed by said host computer.

28. (Amended Two Times) An interface device as recited in claim 27 wherein said location [locations] includes a location [the locations] of an icon [icons] displayed by said host computer.

29. (Amended One Time) An interface device as recited in claim 19 wherein said handle is a joystick.

30. (Amended One Time) An interface device as recited in claim 19 wherein said handle is a mouse.

31. (Amended Two Times) An interface device as recited in claim 19 wherein said embedded microprocessor receives display information from said host computer over said communication bus.

32. (Amended One Time) An interface device as recited in claim 19 wherein said tactile sensations include a viscous drag force.

33. (Amended One Time) An interface device as recited in claim 19 wherein said tactile sensations include an attractive force.

34. (Amended Two Times) An interface device as recited in claim 33 wherein said attractive force is used to assist a user in positioning said displayed graphical pointer into said displayed graphical menu.

35-36. (Canceled)

37. (Amended Three Times) An interface device as recited in claim 21 [19] where said z-axis actuator is a flat coil actuator.

38. (Amended Two Times) An interface device as recited in claim 37 wherein a [the] magnet associated with said [at least one] flat coil actuator is fixed with respect to said origin and wherein said [the] flat coil actuator moves with respect to said origin.

39. (Amended Two Times) An interface device as recited in claim 19 wherein said embedded microprocessor receives code over a communication bus from said [a] host computer and executes said code, said communication bus including a serial interface bus.

40. (Canceled)

41. (Amended Four Times) A device for use in conjunction with a host computer including a computer display, said host computer displaying a graphical environment including a displayed graphical pointer controlled by a user, said device comprising:

a handle to be manipulated manually by said user in at least two planar degrees of freedom;

a z-axis actuator to generate a tactile sensation to be felt by said user, said z-axis actuator applying forces to a hand of said user [the user's hand] only along a z-axis degree of freedom when current is flowed through a portion of said z-axis actuator, said z-axis degree of freedom being different from and substantially perpendicular to said at least two planar degrees of freedom;

a sensor that produces a locative signal responsive to and corresponding with a position or motion of said handle in said at least two planar degrees of freedom;

a button that produces a status signal in response to being pressed by said user; and

a control electronics local to said device and coupled to said sensor and said actuator and said button, said control electronics performing the following:

sending handle movement data and button data to said host computer over a communication bus such that said host computer can update a displayed pointer location in said displayed graphical environment.

receiving a force value from said host computer, said force value correlated with said updated displayed pointer location, and

controlling said z-axis actuator in accordance with said received force value so as to provide said tactile sensation to said user that is correlated with a [the] location of said displayed graphical pointer displayed within said displayed graphical environment.

42. (Amended Four Times) A device as recited in claim 54 wherein said embedded microcontroller runs a program contained, at least in part, in a memory coupled to said embedded microcontroller, and wherein said memory also stores location information which corresponds with image data from a computer display coupled to said host computer.
43. (Amended One Time) A device as recited in claim 42 wherein said location information includes information relating to a [the] location of an icon on said graphical display.
44. (Amended One Time) A device as recited in claim 42 wherein said location information includes information relating to a [the] location of a window on said graphical environment [display].
45. (Amended One Time) A device as recited in claim 42 wherein said location information includes information related to a [the] location of a graphical button on said graphical environment [display].
46. (Amended One Time) A device as recited in claim 42 wherein said graphical environment [images] includes a cursor interacting with another object displayed on said computer display.
47. A device as recited in claim 46 wherein said cursor interacts with an icon image displayed on said computer display.

48. (Canceled)

49. (Amended Three Times) A device as recited in claim 41 wherein said at least two planar degrees of freedom are [planar.] linear degrees of freedom.

50. (Canceled)

51. (Amended One Time) A device as recited in claim 41 wherein said control electronics calculates force feedback forces based on commands received from said host computer.

52. (Amended One Time) A device as recited in claim 41 wherein said handle is moveable in a plane.

53. (Amended One Time) A device as recited in claim 52 wherein said handle is also moveable along a z-axis that is approximately perpendicular to said plane.

54. (Amended Three Times) A device as recited in claim 41 wherein said control electronics include an embedded microcontroller.

55. (Amended One Time) A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed graphical menu to enable said user to more easily select a menu item from said displayed graphical menu by

providing tactile feedback to said user when said displayed graphical pointer is moved from one menu item to a next menu item in said graphical menu.

56. (Amended One Time) A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed button.

57. (Amended One Time) A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed window.

58. (Amended One Time) A device as recited in claim 41 wherein said tactile sensation is applied to correspond with said displayed pointer interacting with a displayed icon.

59. (Amended Four Times) An interface device for use with a host computer displaying a graphical application on a display device, said host computer displaying, executing, and updating graphical objects in a graphical environment in response to user manipulation of said interface device and commanding force feedback sensations in response to said user manipulation and in coordination with said graphical objects, said graphical objects including a graphical pointer, said [the] interface device comprising:

a physical object grasped and manipulatable by a user in two planar degrees of freedom;

at least one z-axis actuator coupled to said physical object for receiving a force control signal and imparting forces along at least one degree of freedom of said physical object and in accordance with said force control signal, said forces applied along a z-axis degree of freedom that is different from and substantially perpendicular to said two planar degrees of freedom;

a sensor that detects motion of said physical object along said at least one degree of freedom and outputs signals relating to a [the] position of said physical object;

a user-adjustable switch apparatus providing a state signal representing a state of said user-adjustable switch apparatus; and

a microprocessor local to said interface device, separate from said host computer, and coupled to said host computer, to said sensor, and to said switch apparatus, said microprocessor receiving

force values from said host computer, said force values correlated with particular locations of said graphical pointer in said graphical environment displayed by said host computer,

said state signal from said user-adjustable switch apparatus, and

said signals from said sensor,

said microprocessor executing a process in parallel with said displaying, executing, and updating graphical objects [host execution of said graphical application] and providing said force control signal to said at least one z-axis actuator to impart said forces in accordance with said [received] force values so as to provide tactile sensations to said user that are correlated with a [the] location of said displayed graphical pointer.

60. (Amended Two Times) The interface device as recited [claimed] in claim 59 wherein said graphical objects include a displayed graphical menu, wherein said tactile sensations enable said user to more easily select a menu element from said displayed graphical menu by providing said tactile sensations to said user when said graphical pointer is moved from one menu element to a [the] next menu element in said displayed graphical menu.

61-62. (Canceled)

63. (Amended Four Times) A method for controlling a force feedback interface device using a host computer, said force feedback interface device manipulated by a user, a display device coupled to said host computer displaying a graphical user interface including images and updating said graphical user interface in response to said manipulation of said force feedback interface device, said force feedback interface device conveying force feedback sensations to said user in response to said manipulations, said [the] method comprising:

 sending a position signal to said host computer, said position signal including information representative of a [the] motion or position of a handle of said force feedback interface device in two planar degrees of freedom, said handle being physically manipulated by said user, wherein said host computer updates a [the] location of a cursor within said graphical user interface in response to said position signal;

 receiving a force value from said host computer with a microprocessor local to said force feedback interface device, said force value correlated with said location of said cursor; and

 controlling a z-axis actuator in accordance with said received force value to provide a tactile sensation to said user that is correlated with said location of said cursor in said graphical user interface, said tactile sensation being applied to a hand of said user [the user's hand] along a z-axis degree of freedom, said z-axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom.

64. A method as recited in claim 63 wherein a sensor signal is input to said microprocessor, said microprocessor calculating said position signal based on said sensor signal, said microprocessor sending said position signal to said host computer.

65. A method as recited in claim 63 wherein said handle includes a joystick that can be moved by said user in two degrees of freedom.

66. A method as recited in claim 63 wherein said graphical user interface provides graphical objects for interfacing with an application program running on said host computer, said graphical objects including an icon, a window, and a menu.

67-75. (Canceled)

76. (Amended Four Times) A human-computer interface device for controlling a graphical cursor displayed by a host computer and for providing tactile feedback to a user in accordance with displayed interactions between said graphical cursor and other graphical objects displayed by said host computer, said interface device comprising:

a physical object to be moved by a user in two planar degrees of freedom;

one or more sensors that produce a locative signal response to and indicative of a [the] position of said physical object in said two planar degrees of freedom;

a z-axis actuator that applies force to a hand of said user [the user's hand] only along a z-axis degree of freedom when current is flowed through a portion of said z-axis actuator, said z-

axis degree of freedom being different from and substantially perpendicular to said two planar degrees of freedom; and

a microprocessor separate from and in communication with said host computer, said microprocessor coupled to said one or more sensors and to said z-axis actuator, wherein said microprocessor receives desired force values from said host computer, said desired force values correlated with particular pointer locations displayed by said host computer, said microprocessor controlling current through said portion of said actuator in accordance with said desired [received] force values.

77. (Amended One Time) An interface device as recited in claim 76 wherein said two planar degrees of freedom are x and y axes parallel to a flat surface on which said interface device rests and said z-axis degree of freedom is substantially perpendicular to said x and y axes.

78. (Amended One Time) An interface device as recited in claim 76 wherein said interface device is a mouse device and wherein said physical object is a mouse.

79. (Amended One Time) An interface device as recited in claim 76 wherein said z-axis actuator includes a wire coil through which said current is flowed.

80. (Amended One Time) An interface device as recited in claim 79 wherein said z-axis actuator includes a magnet core.

81. An interface device as recited in claim 80 wherein said magnet core is an E-core.

82. (Amended One Time) An interface device as recited in claim 76 wherein said one or
more sensors is an optical sensor.

83. (Amended One Time) An interface device as recited in claim 82 wherein said one or
more sensors is an encoder.

84. (Amended One Time) An interface device as recited in claim 80 further comprising a permanent spring coupled between said physical object and said actuator.

85. (Amended One Time) An interface device as recited in claim 76 wherein said z-axis actuator is controlled to indicate when said [the] graphical cursor displayed by said [on the] host computer is moved from one displayed menu element to another displayed menu element.

86. (Amended One Time) An interface device as recited in claim 76 wherein said z-axis actuator is controlled to indicate when said [the] graphical cursor displayed by said [on the] host computer crosses a window boundary.

87. (Amended One Time) An interface device as recited in claim 76 wherein said z-axis actuator is controlled to apply said force to said [user's] hand to indicate when said [the] graphical cursor displayed on said [the] host computer is positioned over a graphical element.

88. (Amended One Time) An interface device as recited in claim 76 wherein said actuator includes a portion that is moveable by said user along a z-axis control to said host computer.

89-91. (Canceled)

92. (Amended Two Times) An interface device as recited in claim 76 wherein a physical tactile element is physically coupled to said actuator and is moved to contact and apply pressure to said [user's] hand.

93. (Amended One Time) An interface device as recited in claim 92 wherein said physical tactile element applies pressure upon said [the user's] hand by pressing upward on said hand when said current is flowed through said portion of said z-axis actuator.

Claims 95-108. (Canceled)